DOCUMENT RESUME

ED 262 110 UD 024 383

AUTHOR Cooke, Lloyd M.
TITLE Design for Excellence: How to Study Smartly.
INSTITUTION National Action Council for Minorities in Engineering, Inc., New York, NY.
PUB DATE 84
NOTE 31p.
AVAILABLE FROM NACME, Inc., 3 West 35th Street, New York, NY 10001 ($0.50 plus postage).
PUB TYPE Guides - Classroom Use - Materials (For Learner) (051)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Engineering Education; Higher Education; *Homework; Minority Groups; Study Guides; *Study Habits; *Study Skills

ABSTRACT

This brief guide on how to study efficiently was designed for minority engineering students and provides eight techniques to improve study habits and enhance learning and retention. The first seven suggestions are each accompanied by a methodology and an explanation of the purpose of the technique; the eighth pertains to the overall concept of using study time well and how the previous seven suggestions can enable students to do so. The eight suggestions are: 1. Study the most important principles and processes first; 2. Focus on what you have not yet mastered; 3. Periodically re-study important material you have already mastered; 4. Do homework within two days of the assignment; 5. Get help if you can't solve a new problem after one hour; 6. Join a study group to keep up with homework; 7. Check your academic progress every week; and 8. Use the concept of "time-on-task" to study efficiently. The booklet includes a study schedule form, brief references, and a capsule version of the study suggestions. (CG)

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DESIGN FOR EXCELLENCE:

How to Study Smartly

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NACME's mandate is to encourage the implementation and expansion of local programming that will identify, attract, prepare, and graduate students who will enter the engineering profession. As the central organization and catalyst for the national minority engineering effort, NACME performs those tasks that are best done nationally while assisting regional and local programs to do what is more effectively done at the local level.

NACME therefore seeks to increase the number of institutional participants in the national effort: corporations, foundations, universities, professional societies, school districts, community and minority organizations, and government bodies.

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DESIGN FOR EXCELLENCE:

How to Study Smartly

by Lloyd M. Cooke

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PREFACE

This booklet is about a skill you need in order to become a successful engineering student, and to achieve excellence in engineering. This skill is not often taught to students, but you can learn it on your own. That skill is *how to study efficiently – how to get the most out of the time you set aside for study – how to study smart(ly).*

Some colleges have special programs to help minority students learn to study efficiently. Others do not. We have studied the most successful of these special programs for minority students and have examined research data on teaching and learning. From all this we have compiled a number of suggestions you can use *on your own* to improve the efficiency of your study.

Each section of the booklet tells you something you can do to improve your study habits. Although each smart study suggestion is self contained, a common thread runs throughout. Wise students will try four or five study suggestions and end up doing two or three regularly. We have included a short version of the suggestions that you can cut out and carry with you. You may want to laminate it in plastic, or make photocopies of it to remind yourself.

The longer version of the suggestions explains exactly *how* you can study more efficiently, and *why* these suggestions will work for you.

Engineering is a profession that demands and rewards excellence. Our purpose in this booklet is to help you reach the highest level of learning you can reach. It is a Design for Excellence.

Acknowledgments

My thanks go to the following successful directors of minority engineering programs. They provided valuable encouragement, constructive criticism and freely shared their experience.

Margaret Boulding,
Case Western Reserve University
William Gamble, Georgia Institute of Technology
Wesley Harris,
Massachusetts Institute of Technology
Raymond Landis, California State University,
Northridge
Gerald Paskusz, University of Houston
Nathaniel Thomas, Illinois Institute of Technology

Thanks go also to Professor Ralph Jenkins, Temple University for his contribution to the writing style of the text.

Lloyd M. Cooke
President Emeritus
NACME, Inc.

I. Study the most important principles and processes first.

How:

Some professors point out the most important things you should learn from their courses. For example, a forty five minute lecture on the gas laws might include the theory behind the laws and several applications of the laws. All that information is useful and helps you understand the fundamental combined formula, $PV = n RT$. Many professors will spotlight this formula as the most important thing for you to remember and to practice using. Unfortunately, most professors don't do this. That means you must make a special effort to find out what to focus on when you study. Ask for advice from your tutors or other instructors, or see what questions were asked on old exams. Or ask your professor to pinpoint the most important parts of his lectures and assignments.

If these suggestions don't help you, then you must use your own judgment in deciding what to study. Some professors assign relatively unimportant examples and problems along with the important material because they want to cover all aspects of their

subject. But no student has time to study and re-study everything, so you must learn to identify the most important material. After each class, ask yourself these questions: What parts of today's material are most likely to be on exams? And what parts will I have to know for future courses?

The answers to these two questions may not be the same. Dr. G.F. Paskusz, professor of Electrical Engineering, University of Houston says, "There may be a difference between what is really important and what is likely to be on the exam. The grapevine, course files, and students who have already had the course are good sources of information about what is likely to be on the professor's exam. The short term objective of working for a good grade in the course can be attained that way. But there still remains the much more valuable problem of learning what is most important to prepare one adequately for the next course up the line."

With practice, asking yourself these questions will help you make better decisions about how to use your study time.

Why:

These suggestions come from an educational theory developed by Benjamin Bloom,[1] called Mastery Learning. This theory was tested for five years in several New York City high schools, and seems to be very effective in improving academic achievement, especially in science and mathematics. Mastery Learning is based on the belief that up to 95% of students can reach the high levels of learning usually reached by only the best learners, if they are given the time and quality of instruction they need. The problems are that some students need more time than

the school schedule allows, and the quality of instruction varies greatly. Bloom's strategy is designed to shorten the time a student takes to learn something.

The teacher who prepares a course using Mastery Learning theory first defines what "mastery" means. What things must the student be able to do show mastery in the course? These are called *instructional objectives*. The teacher then arranges these objectives into a series of units, so that each new unit uses and adds to the material learned in earlier units. Next, the teacher constructs brief, ungraded tests to be scored by the student. These are called *formative tests*. Their purpose is to tell the teacher how much of each course objective the student has grasped. Finally, the teacher prepares a set of materials called *correctives*. These teach the objectives of the course in ways different from the classroom instruction.

The teacher then begins teaching the units in sequence. At the end of each unit, he gives students the formative test to find out what each student has learned. Students who have *not* learned then use the correctives to complete their learning for that unit. When all units have been completed, the teacher gives the final or *summative* test. The results of that test usually determine the student's grade in the course. If the student has achieved mastery, as it was defined at the beginning of the course, he or she gets an A. Lower levels of achievement result in lower grades, but few students earn below C.

Not many college professors use Mastery Learning theory fully. However, you can use it yourself to some degree even in an ordinary course. For example, when you ask yourself and others what is most important for you to study in a course, you

are defining for yourself the *instructional objectives* of the course, even if the instructor has not defined them for you. My goal as author of this booklet is to enable all students to exploit the principles underlying Bloom's findings *on their own*, even when a teacher does not use Bloom's ML teaching techniques. Other sections of this booklet will show you how to put into practice the other parts of Mastery Learning theory.

And keep in mind as you study: it will do you little good to half-understand the principles and procedures of engineering. To solve the problems you will face as a student and an engineer, you must fully understand those principles and procedures, and be able to apply them. That is, you must *master* the material you study.

Dr. Wesley Harris, professor of Aeronautics and Astronautics, M.I.T., says that *mastery* and *excellence* mean the same thing. *Excellence* is what you should strive for in your study of engineering.

II. Focus on what you have not yet mastered.

How:

You won't always get the right answers on your tests and homework papers. You may be embarrassed by your wrong answers, and be tempted to ignore them. But wrong answers give you very useful information. Wrong answers tell you precisely what you have not yet mastered and, therefore, what you must study harder.

First, look over your tests and homework to see what answers you got *wrong*. Then spend 30 to 90 minutes of your study time going over those problems and questions again, learning how to get the *right* answers. Now, check to see that you have mastered this material. Here are two ways to check:

1. If your professor requires a textbook, or recommends one, find several problems in it that use the principles or procedures you have just studied. Try to solve those problems. If you can solve them, you have now learned the material.
2. If your professor doesn't require or recommend a textbook, or if you can't find any problems to solve that cover the material you've studied, do this: Imagine that you have to explain the material to another student. In your own words, *write out* one or two paragraphs as if you were talking to that other student.

Don't stop here. Now discuss what you have just studied with someone else. Go to a tutor, or a classmate who seems to understand the material, or an instructor. Show that person your solutions to the problems, or your written explanations. Does he or she agree and

understand? If so, you know that you now understand the principle, law, or procedure you have been studying.

Ideally, you should follow these suggestions for only the most important material in the course. In Section One, we told you how to decide what is most important. But what if you aren't sure what to study in this way? Then it's a good idea to study some of the material you think may or may not be important. You may waste some of your study time if the material you focus on is not included in future coursework or exams. But you will waste more time if you try to study *everything* covered by lectures and textbooks. After all, you have already mastered some of that material. The most efficient way to use your study time is to study *first* and *hardest* the most important things you have not yet mastered.

Why:

When you follow the advice we have just given you, you are doing some of what we described in Section One when we discussed Mastery Learning theory. A necessary step in learning something is to find out what you can do already, and what you cannot do. Your *wrong* answers on tests and homework are like the formative tests used in Mastery Learning—they tell you what you have not yet learned. Studying the material again, solving new problems your instructor did not assign, and writing paragraphs of explanation are ways of learning that are different from classroom instruction, like the *correctives* in Mastery Learning.

You can count on your professor or your instructor to tell you what you did wrong. But it's up to you to fight the urge to ignore your mistakes because of embarrassment. Finally, it's *your* responsibility as a future engineer to study the material in new ways. You are the one who will benefit from mastering it.

III. Periodically re-study important material you have already mastered.

How:

In Sections One and Two we told you how to schedule most of your study time. First, study the most important new material. Then study old material you have not yet mastered. But you should also plan to spend some of your study time going back over important material you have already mastered, so that you don't forget it.

A good way to do this is to go back and solve some problems you already know how to solve, or have solved before. First, decide what principles and procedures you must know for exams and future course work, as we described in Section One. Then find some problems that use those principles and procedures. Here are some ways to find problems:

- Keep your old homework papers and exams when your instructor returns them. Mark in red some problems you solved correctly.
- Look in the early sections of the textbook your instructor has assigned for the course.
- Find a different textbook in the same subject, in the library or bookstore. Take problems from it.
- Ask your instructor if there are files of old exams you can look at. Your instructor may even point out the most important problems.
- Ask your tutor or fellow student for problems from their homework or exams.

Why:

You should do this because of the way most engineering and math courses are arranged. These courses have a *hierarchical* order. That is, the instructor presents the basic skills and elements first, and then goes on to the higher-level material. But "basic" does not mean the same as "simple." "Basic" means fundamental-that is, this early material is the foundation on which all the later material in the course is based. If you don't learn the basic material well in the beginning, then it is very hard, if not impossible, to learn the next steps. It's very much like trying to build a stone archway with several of the foundation pieces missing: the chances of your being able to put the top stone in place are pretty slim, to say nothing of having it *stay* there.

For this reason it's wise to refresh your memory of the basic material regularly. Some instructors schedule periods for review of old material into their course calendars. Others regularly give a few "old" problems in their homework assignments. If your instructor doesn't do this, you should schedule review sessions into your regular study time, and stick to your own schedule.

Going back over material you have already mastered will reinforce your memory of important principles and procedures. And it will give you confidence in your ability to master new material.

IV. Do homework within two days after it's assigned.

How:

When your professor introduces a new principle, concept, or procedure in his or her lectures, do your assigned homework as soon as possible. Schedule your study time so that you practice using these new ideas *within two days*. If there is no assigned homework, find ways to practice using the new material on your own. In Section Two we suggest some ways to do that.

Why:

It's very important to do your homework promptly even though it may not count for more than 20% of your course grade. Doctor Gerald Paskusz, Professor of Electrical Engineering at the University of Houston, explains why. He says that the purpose of homework in engineering, physics, and math courses is to give you practice in applying new and important principles. Those new principles may seem clear to you when your professor first explains them. But you will be taking classes and labs in several different subjects, and you will forget the explanations quickly unless you use the principles to solve problems. And once you have forgotten the explanations, you will have to spend valuable study time re-learning—time that you could better spend studying something else.

Dr. Raymond Landis, Professor of Mechanical Engineering at California State University, Northridge, also explains why students should do homework promptly. He says that students retain some information and learn more efficently when they study and master new material within several hours after it is first presented. He advises his students always to master the material presented in each class *before the next class session comes.*

Dr. Landis goes on to say, "Another principle I try to instill in students is to treat their scheduled time with the same commitment as a class. Students will decline invitations or requests when they have a class. Since study time is at least as important, if not more important than class time, it is imperative for students to look on their study time as a firm commitment."

David Ellis[2] adds, "Studies have shown that one week after receiving meaningful information, [students] were able to recall only about 60% of the material. However, when the same volunteers reviewed the same kind of material within 24 hours, they were able to recall 90% of the material.—Review your notes right after class. Review reading within one day. Fifteen minutes of review after a class will save hours of study time later on when final exams approach."

V. Get help if you can't solve a new problem after one hour.

How

In earlier sections of this booklet, we suggest ways to study and to schedule your time. Now suppose you've followed this advice. You've worked hard for an hour trying to solve a problem or answer a question on your homework. But you still can't get the answer. The concept or principle just doesn't make sense to you. What do you do now?

Don't give up. But don't waste any more of your study time working by yourself, either. Get help. Go to a tutor, or to a classmate or an instructor who is willing to help. Or go to your study group, which we discuss in Section Six. Get someone to go over the problem or question with you until you understand the principle or procedure involved.

Remember: *one hour*, plus or minus fifteen minutes, is a realistic limit to place on unproductive study. If you're not getting good results after an hour of hard work by yourself, get help.

Why:

Of course it's true you must learn to solve problems independently. But you must also master your course material. You simply don't have enough study time to keep working on problems you can't solve by yourself after reasonable effort. You also have the pressing problem of getting the rest of the day's homework done before the next

assignment comes along.

By seeking help when you need it, you are learning to study efficiently, to make the best use of your valuable study time. And as you improve your study habits, you may find yourself becoming a more independent problem solver.

VI. Join a study group to keep up with homework.

How:

In Section Five we discuss how to get help when you aren't getting results from your study time. One way to get help is to join an *organized study group*. A study group is usually made up of two or three students who are taking the same course or courses. They agree on regular times to meet and work together on homework and preparation for exams.

The study group is in addition to individual study, not a substitute for individual study. It's a give-and-take arrangement. When you are having difficulty solving a particular problem or understanding a concept, the other members of your group help you by discussing it or explaining it to you. In return, you help them when they have trouble with something you understand. When your scheduled meeting is over, the members of your group return to individual study.

Some colleges and universities help students organize groups, or even require attendance in groups as part of special programs. If your college doesn't do this, you can still get the benefits of group study. Find one or two other students in your classes that you can *work* with—students who do their assignments and are willing to help one another. Agree on a place to meet, and set regular meeting times. Then stick to your schedule.

Why:

Good students for years have formed study groups on their own. Recently, some engineering programs have been organizing study groups with good results. At Case Western

Reserve University, the minority student retention program directed by Ms. Margaret Boulding organizes students into groups of two or three according to the classes they are taking. The groups meet two or three times a week. Each student is responsible for reading any assigned material and trying to do the assigned homework or problems. Students then work together in the groups to solve the more difficult problems and improve their understanding of the concepts.

Ms. Boulding reports, "This approach appears to be effective. Since we have incorporated group study into our program, our freshmen have earned higher grade point averages than their predecessors. Our records indicate that those students attending the study labs and participating in group study have performed much better than those students who have done neither of the above. We believe that a well-structured study situation will benefit any student, but especially [those who] suffer from weak study habits."

Dr. William Gamble, Director, Office of Minority Educational Development, Georgia Institute of Technology says: "I personally feel this section deserves special attention. Engineers usually work as a team. Students can prepare themselves for professional team work by getting in the habit of studying in groups."

Regular attendance at group sessions may help you develop good study habits. And there may be other benefits. Different students may take different routes in solving a problem. Listening to your fellow students may thus help you learn other thinking patterns, new ways to go about solving difficult problems.

Additional experience with group study at Illinois Institute of Technology is voiced by M.E.P. Director, Nathaniel Thomas, "I agree with all your studied premises, especially group study since I have used it successfully for years. I did this because it made good common sense and it worked, even though I didn't give a name to the process."

VII. Check your academic progress every week.

Some engineering colleges have their own "early warning" procedures to find and counsel students who are not doing well and may be in danger of failing. Your college may or may not have such procedures. But the smart engineering student doesn't wait for a warning from someone else. Develop your own way of checking your progress in your courses *each week*. That way you can take corrective action when you need it, before it's too late.

Here are some things to watch for.

- *Are you more than two days behind in your homework?* There is so much work in engineering courses that you must stay on schedule to succeed. If you are two days behind in your assignments, you may need to give yourself more time to study, or you may need to study in different ways. Sections Four, Five, and Six of this booklet offer suggestions that may help.
- *Are you scoring less than 70% on homework and tests?* Lower scores may mean that you have not mastered the material presented so far. And the material that comes later builds on this early material. You may need to review the basics, as we suggest in Section Three. And you may need to focus on what you have not yet mastered, as we suggest in Section Two.
- *If you belong to a study group, do you get more help than you give?* If so, you may not be spending enough time in individual study. Or you may not be focusing on the right things. See Sections One, Two and Three for suggestions.

- *Do you feel lost, as if you just don't understand?* If so, the way the material is being presented in class or in your textbook may not be working for you. Try forming a study group to get other approaches to the material, as we suggest in Section Six. Or look for a different textbook on the subject, in the library or book store. Try asking questions in class to check your understanding. Try solving some problems your instructor did not assign. Try writing out a paragraph or two of explanation of the material you don't think you understand. We discuss some of these ways to check your understanding in Section Two.

Use these warning signs to check your own progress and understanding *every* week. If you're falling behind or not doing as well as you should, don't be shy. And don't wait until it's too late. Get help from your instructor, your tutors, your study group, or your fellow students. There are always people who are willing to help if you ask them.

VIII. Use the concept of "time-on-task" to study efficiently.

The concept:

According to Harvard Professor, John Carroll,[3] people are not "good learners" or "poor learners." Instead, they are "fast learners" or "slow learners." Research that Professor Carroll did in the 1950's and 60's shows that both fast and slow learners can finally learn almost all that is taught in secondary schools and colleges--if they have enough time and motivation. Professor Carroll developed a principle called the Carroll Learning Function. Basically, it says that the degree of learning you achieve equals the amount of time you actually spend on learning divided by the time it takes you to learn. That is,

$$\text{Degree of learning} = \frac{\text{Time spent on learning}}{\text{Time needed to learn}}$$

Think about this for a minute. If ProfessorCarroll is right, what the Learning Function says is that there are basically two ways to increase your degree of learning. You can spend more time actually learning. Or you can reduce the amount of time it takes you to learn. The smart engineering student constantly looks for ways to improve the degree of his or her learning. This booklet is about ways you can do that.

How to use the concept:

If you aren't spending enough time studying, the first thing to do is obviously to spend more time. But if you are already spending all the time you have for studying, then you may be able to increase the time you spend *actually learning* by spending your study time *more efficiently*.

Throughout this booklet we advise you to schedule your time--set aside certain hours for studying certain subjects, and stick to your schedule. Make a serious commitment to study. Take your

scheduled study time as seriously as your scheduled class time. In Section Five we advise you how to limit the amount of time you spend on unproductive study, study that doesn't produce results. In Section Six we discuss the techniques and benefits of group study. All these are ways of using your study time efficiently.

But there is always a limit to the amount of time you can spend in study, and to the efficiency you can achieve. So you must also seek ways of reducing the *amount of time* it takes you to learn. Here are some of those ways.

- Concentrate on the most important material, the critical elements. Section One of this booklet tells you how and why.
- Concentrate on what you *haven't* learned, not on what you have already learned. Section Two tells you how and why.
- Review the basic elements regularly to improve your memory retention. Section Three tells you how and why.
- Study promptly when new material is assigned, to reduce the amount of material you have to re-learn. Section Three tells you how and why.
- Find different ways to learn. If one way doesn't work for you, try another. We discuss this in Sections Two and Six.

A recent graduate in Civil Engineering said, "Wise students learn to step back from their situations periodically to make sure they are not spinning their wheels." One way to do this is to consider the Carroll Learning Function. As you know, a fraction (degree of learning) increases if you increase the numerator (time actually spent on learning) or if you decrease the denominator (time needed to learn). Think of your own education as an engineering problem you are solving. To increase the degree of your learning, find ways of changing both the numerator and the denominator of the Carroll Function.

In the other sections of this booklet, we suggest how to decide what to study, and ways to study. You also need to decide when to study and where. As an engineering student, you will probably have to do five to ten times as much homework as you did in high school. Few beginning

students really know, at first, how much time and energy is needed for success. Many engineering schools, therefore, have special programs to help minority students learn to focus their attention and schedule their time. If your school doesn't have a study skills program, you can use the suggestions in this booklet to learn to study efficiently. It is very important for you to *manage your time well*, to schedule definite times and places for studying specific subjects. To help you with this, we've included here a schedule form that Dr. Raymond Landis teaches his students to use. He says,

"My approach is to have the student schedule his or her entire week as follows:

1. Write down all your commitments on the form. These include classes, meetings, job, travel, and so on.
2. The rest of your time is available for either study or recreation.
3. Schedule blocks of time to study. Write down both *where* you will study, and *what subjects* you will study."

Dr. Landis finds that this approach improves the student's efficiency. That is, once you have scheduled your time, you don't have to keep making decisions about whether to study, and when, and where, and what. Once you have scheduled your time, stick to your schedule. Academic success comes only when you have learned to study efficently.

As you become more efficent in your study, you may want to allow more time for some subjets, and less for others. Fine. But don't give up scheduling. Simply change your schedule. Make new commitments to yourself and keep them. Since time management is basic to engineering, you are practicing a skill you will use throughout your engineering career.

Each of the professors and engineering student program directors who have reviewed this booklet has made some comment about the heavy work load which engineering students must carry. Dr. Gamble at Georgia Tech. says, "Learning and Studying mean work. Students must understand that a commitment to learning by studying (up to 8 to 10 hours per day) means also a commitment to work.

LANDIS STUDENT SCHEDULE FORM

	SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
0- 9							
9-10							
10-11							
11-12							
12- 1							
1- 2							
2- 3							
3- 4							
4- 5							
5- 6							
6- 7							
7- 8							
8- 9							
9-10							

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Matthew O'Brien
Comptroller

Lloyd M. Cooke
President-Emeritus

HOW TO STUDY SMARTLY

CAPSULE VERSION

What To Do:

I. **Study most important material first.**
Find out which principles and processes you must know for examinations and future coursework. Do this by asking tutors, or other instructors, or by studying old exams. Or ask your professor to point out the most important parts of his lectures and assignments.

II. **Focus on what you have not yet mastered.**
What answers did you get *wrong* on your tests and homework? Spend 30 to 90 minutes studying those problems and principles. Then check your results with someone else.

III. **Periodically re-study important material.**
Schedule some of your study time for going back over earlier material you expect to find in exams in future courses. Solve again some problems you have already done. This helps you remember important principles.

IV. **Do homework within two days.**
Get to work right away when your teacher introduces a new subject, or new principle, or new procedure. Do your assigned homework or practice within two days, to improve your memory.

V. **Get help after one hour's fruitless study.**
You've worked hard for an hour trying to solve a new problem or understand a new concept. But it still doesn't make sense. What do you do? Don't give up, but don't waste any more time either. Get help from a tutor, a fellow student, or an instructor.

VI. **Join a study group to keep up with homework.**
Find one or two other students taking the same courses you are taking. Agree on regular times to meet and help each other with difficult problems and concepts.

VII. **Check your academic progress every week.**
Develop an "early warning system" of your own. Are you getting behind in homework? Are you getting poor grades? Do you feel you aren't understanding the material? If the answer to any of these is yes, don't wait. Get help from a tutor, an instructor, or a fellow student.

VIII. **Use "time-on-task" concept to study well.**
Schedule study time and stick to your schedule. Find ways to use your study time more efficiently, and ways to reduce the time it takes you to learn. Use the sections of this booklet to find out how.